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Diel Fluctuations in the Catch of Larval Gulf Menhaden, *Brevoortia patronus*, at Galveston Entrance, Texas[1]

INTRODUCTION

A critical period in the life cycle of Gulf menhaden, *Brevoortia patronus*, occurs as the ocean-spawned larvae move through inlets from the Gulf of Mexico to estuarine nursery areas (Fore, 1970). The mechanism used by estuarine-dependent larvae to remain in this habitat in spite of the strong tidal currents is not understood. While in the estuaries, menhaden larvae metamorphose to juveniles, and these young remain in low salinity waters during the spring and summer before returning to sea in the fall.

The purpose of this paper is to report catches of larval Gulf menhaden made in a series of collections during a 96-hour period at the mouth of Galveston Bay and to relate these catches to certain environmental conditions.

STUDY SITE, SAMPLING GEAR, AND PROCEDURE

Plankton samples were taken every 2 hours over a 96-hour interval at Galveston Entrance, Texas, from 1–5 April 1963. The sampling station was along the shoreline inside the entrance between the north jetty and the Fort Travis ruins on Bolivar Peninsula. The bottom at this site consisted of shell fragments and firm sand.

Plankton tows were made with a hand-drawn beam trawl (Renfro, 1963) by personnel of National Marine Fisheries Service, Galveston, Texas, during studies of the distribution of larval shrimp. The beam trawl was 1.5 m wide along both cork and lead lines and 0.7 m long, with a plankton net of #1 mesh (aperture of 0.480 mm) attached for the cod end. Wings of nylon netting were secured by cables to a 1.8-m beam of steel pipe. The mouth opening of the trawl was approximately 0.5 m^2.

A standardized sampling procedure was followed during each collection. One end of a 46-m line was tied to a stake driven into the sand at the edge of the water. The operator held the outermost end of the taut line in one hand and the bridle of the trawl in the other. The gear was then pulled along the bottom in a semicircular arc from the shoreline. The average volume of water strained during a standard tow was 70 m^3. Plankton samples

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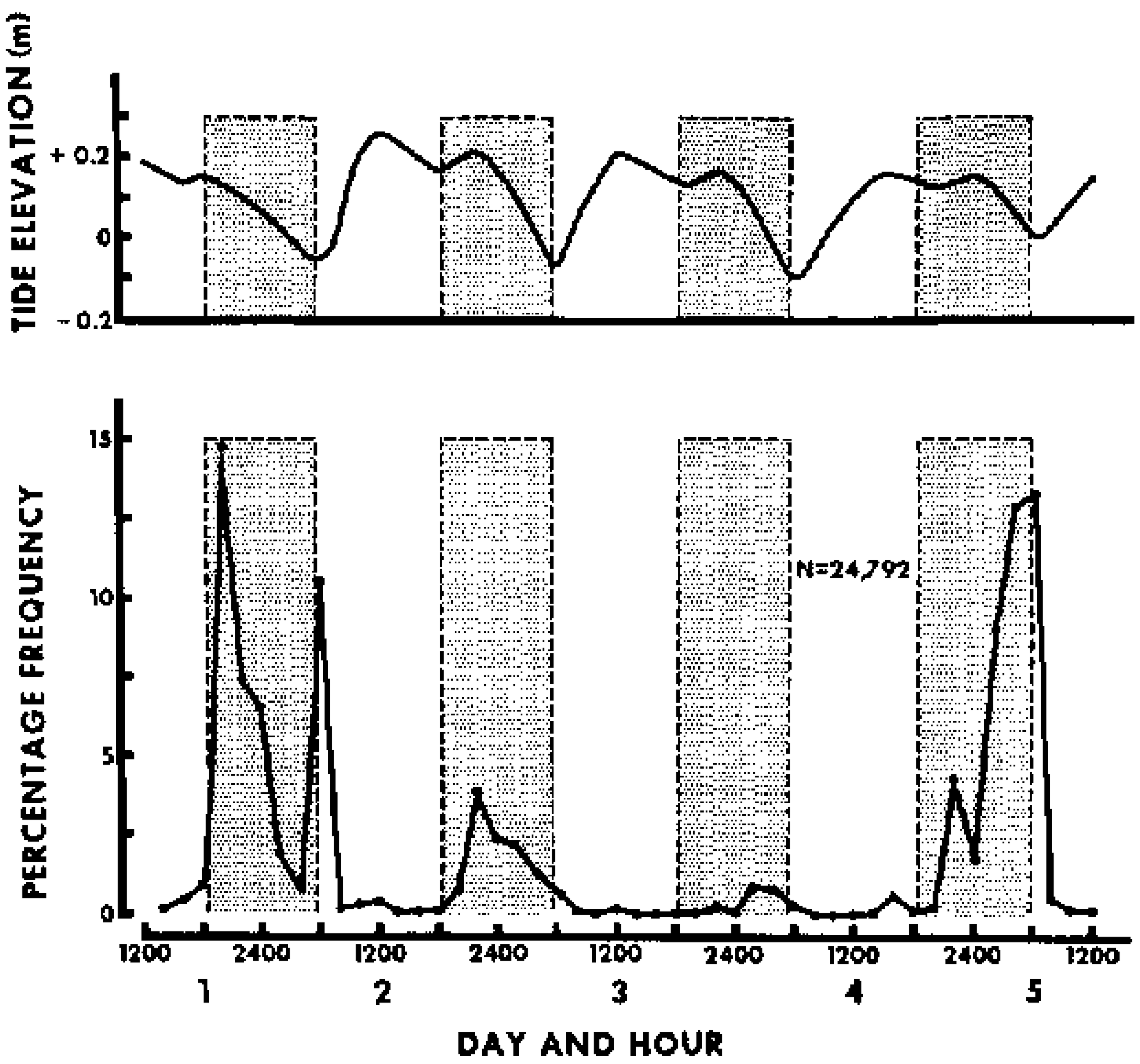

FIGURE 1.—Frequency distribution in the catches of larval Gulf menhaden per tow every 2 hours (bottom) and tidal fluctuations (top) during a 96-hour interval at Galveston Entrance, Texas, 1–5 April 1963. Stippled areas represent periods of darkness, whereas the light areas depict daylight conditions.

were preserved in a buffered, 5% solution of formalin in sea water. Water temperature and salinity, tidal stage, and atmospheric conditions were recorded at the times of sampling. Additional details on the sampling gear and procedure were provided by Baxter (1963).

We transformed catch data logarithmically before analysis to attain homogeneity. Since some tows did not collect any larvae, a value of 1 was added to each catch before the data were transformed.

RESULTS

Variations in day and night catches of larval Gulf menhaden during the 96-hour series are given in Figure 1. A total of 24,792 larval menhaden, ranging in size from 19.5 to 23.5 mm SL, was captured during 48 tows. The average catch contained 516 menhaden larvae. Associated larval fishes were not tabulated because of their infrequent occurrence in the collections.

Peaks of abundance generally occurred at night, except for two peaks on 2 and 5 April at 0600 hours, shortly after sunrise (Fig. 1). During the four nocturnal periods, two peaks occurred in the evening hours and two after midnight. Except for the first samples in low light intensities each morning, few larvae were captured during the day. Also, daylight catches did not increase as a result of the reduction in incident light under overcast skies on 3 and 4 April.

TABLE 1.—*Distribution of day and night catches of larval Gulf menhaden related to tidal stages during a 96-hour sampling series at Galveston Entrance, Texas, 1–5 April 1963*

Item	Day		Night	
	Ebb tide	Flood tide	Ebb tide	Flood tide
Number of tows	14	14	14	6
Total catch	6,489	699	14,770	2,864
Mean catch	464	48	1,055	477

There were abrupt diel fluctuations in catches of larval menhaden. Seventy-one percent (17,634) of the larvae were captured in 20 tows at night (mean catch 882), whereas 7,158 individuals were taken in the 28 daylight tows (mean catch 256). The difference between the mean day and night catches was statistically significant ($t = 4.34$, $p < .05$). Analogous diel catches were reported by Lewis and Wilkens (1971), who used a channel net which collected four times more larvae of the Atlantic menhaden, *Brevoortia tyrannus*, at night than during the day in the strong channel currents of the lower Newport River estuary at Beaufort, North Carolina.

The tides at Galveston Entrance from 1 to 5 April were a mixed semidiurnal type, consisting of two daily tides exhibiting inequality between the two high waters and between the two low waters (Fig. 1). On 2 April, the maximum tidal fluctuation was 0.32 m, whereas the range of the secondary tide was 0.03 m. Generally, the tides at Galveston are diurnal (one tidal cycle per 24 hours), with a yearly mean range of 0.43 m. A general discussion of tidal influences in estuarine waters of the northern Gulf is given by Collier and Hedgpeth (1950) and Marmer (1954).

Comparisons among the four variables of tidal flow and the light and dark cycle (Table 1) revealed that the differences among the mean catches were statistically significant (t-test, $p < .05$), except for the mean catches obtained during the day on ebb tides and at night on flood tides. Maximum catches occurred at night in ebbing waters. Analysis of only the tidal data indicated that significantly more larvae were captured on ebb tides than on flood tides ($t = 2.24$, $p < .05$).

Peak catches corresponded to the predicted times of maximum ebb velocities that occurred at night and to one relatively strong ebb at 0625 hours on 5 April (U.S. Coast and Geodetic Survey, 1963). On ebb tides, the configuration of the pass at Galveston apparently created a strong eddy at the sampling site, since the tidal flat was adjacent to the main channel. Presumably, menhaden larvae were either carried by the currents toward the shoreline or sought the less turbulent waters.

Decreasing water temperatures in the evening were associated with increased catches. A statistical relationship was demonstrated between the catches and water temperatures ($r = 0.54$). Over the tidal flats, temperatures reached a high of 28.0 C in the afternoon of 3 April and a low of 19.5 C in the morning hours of 5 April. The average daily fluctuation was 5.2 C.

No correlation was indicated between the salinity of the water and the catch of larvae ($r = 0.10$). Even with the changes in the tidal cycle, the salinity remained relatively steady, varying from 26.6 to 29.1‰.

DISCUSSION

Significant fluctuations in catches of larval Gulf menhaden were observed during day and night cycles as well as between ebb and flood tides. The decreased catch during daylight hours was attributed to net avoidance. Menhaden larvae evidently detected the operator and bridle in front of the slowly moving trawl and evaded the approaching net. Because there was a marked increase in both day and night catches on ebb tides, we concluded that the displacement of larvae over the tidal flats was more closely associated with water movements than with day and night factors.

The ability of the larvae to maintain their relative positions in the estuary in adverse currents was apparently under the control of a tidal mechanism. To avoid being swept to sea by strong ebb currents, these pelagic larvae evidently moved into the slower flowing waters along the shore, either by swimming, by finding favorable currents, or by a combination of both methods. It is not known how menhaden larvae distinguish between ebb and flood currents, but presumably they are able to detect changes in salinity, in the drift of particulate matter, or in the presence of terrestrial substances.

Supporting evidence of the effects of tidal currents on the distribution of small organisms was provided by Berry and Baxter (1969) during the same 96-hour study. Their figure (p. 783) on the relative abundance of postlarval brown shrimp, *Penaeus aztecus*, was strikingly similar to our data on the percentage frequency of larval menhaden in the catches. The parallelism in the peaks of abundance of these two species during periods of maximum ebb tides suggests that the directions and velocities of flow play an important role in regulating the distribution and catch of larval menhaden and young shrimp in estuarine waters.

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